R E P O R T R E S U M E S

ED 017 124 EF 000 793

THE CRITICAL-PATH METHOD OF CONSTRUCTION CONTROL.

BY- DOMBROW, RODGER T. MAUCHLY, JOHN

NATIONAL COUNCIL ON SCHOOLHOUSE CONSTRUCTION

PUB DATE OCT 63

EDRS PRICE MF-$0.25 HC-$0.44 9P.

DESCRIPTORS- *COMPARATIVE ANALYSIS, *MANAGEMENT, *NETWORKS, *SCHEDULING, *SCHOOL CONSTRUCTION, COMPUTERS, CONSTRUCTION COSTS, SYSTEMS ANALYSIS, TIME, CPM

THIS DISCUSSION PRESENTS A DEFINITION AND BRIEF DESCRIPTION OF THE CRITICAL-PATH METHOD AS APPLIED TO BUILDING CONSTRUCTION. INTRODUCING REMARKS CONSIDER THE MOST PERTINENT QUESTIONS PERTAINING TO CPM AND THE NEEDS ASSOCIATED WITH MINIMIZING TIME AND COST ON CONSTRUCTION PROJECTS. SPECIFIC DISCUSSION INCLUDES--(1) ADVANTAGES OF NETWORK TECHNIQUES, (2) A COMPARISON OF BAR CHARTS AND CPM, (3) THE OPERATION OF CPM, (4) WHEN CPM MAY BE USED, AND (5) A SUMMARY OF ADVANTAGES TO THE OWNER, ARCHITECT, AND CONTRACTOR. SPECIFIC ASPECTS OF CPM ARE--(1) ACTIVITIES, (2) TIME DURATION, (3) ACTIVITY COST, (4) MANPOWER ASSIGNED, (5) FLOAT TIME, (6) CRITICAL ACTIVITIES, (7) COMPLETION DATE, AND (8) COMPUTER PRINTOUT. THIS ARTICLE IS PUBLISHED IN THE PROCEEDINGS OF THE NCSC, 40TH ANNUAL MEETING, PRINCETON, NEW JERSEY, OCTOBER 7-10, 1963. ADDITIONAL COPIES OF THE PROCEEDINGS MAY BE OBTAINED FOR $2.50 FROM THE SECRETARY, COUNCIL ON EDUCATIONAL FACILITY PLANNERS, OHIO STATE UNIVERSITY, COLUMBUS, OHIO. (MM)

ED017124

THE CRITICAL-PATH METHOD OF CONSTRUCTION CONTROL

INTRODUCTORY REMARKS: JOHN MAUCHLY

A presentation of the Critical-Path Method for controlling school construction should cover the following questions:

1. What circumstances led to the development of CPM?
2. What are the advantages of network techniques?
3. How does CPM function?
4. When may CPM be used to maximum advantage?

Let me explore the first question, "What circumstances led to the development of CPM?"

The effective management of modern complex projects with particular emphasis on minimum time and minimum cost creates the following needs:

1. The need for greater coordination among the participating contractors, architects and owners.
2. The need to identify trouble spots and provide a method for evaluating alternative strategies and objectives before and during the life of the project.
3. The need to manage by exception which permits top management to spend time on identified problem areas, thus leaving normal operations to appropriate levels of management.
4. The need for a procedure which will permit the effective transfer of responsibilities at any level of management.
5. The need for a comprehensive project record in readily useful form.
6. The need for optimum start and finish times that have a high degree of reliability.

The remaining questions dealing with advantages of network planning and CPM procedures will be answered by Dr. Dombrow during his presentation, which was prepared by Dr. Daum and Dr. Dombrow.

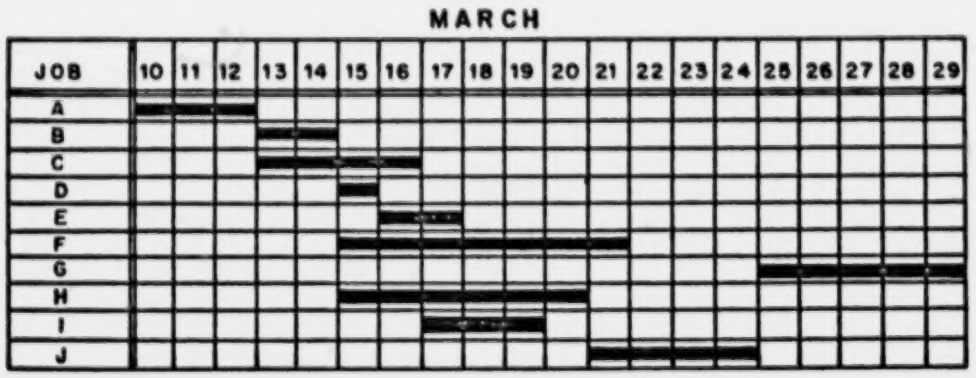
EF000793

Before CPM, all scheduling of work was done with bar charts.

A. What Are the Advantages of Network Techniques?

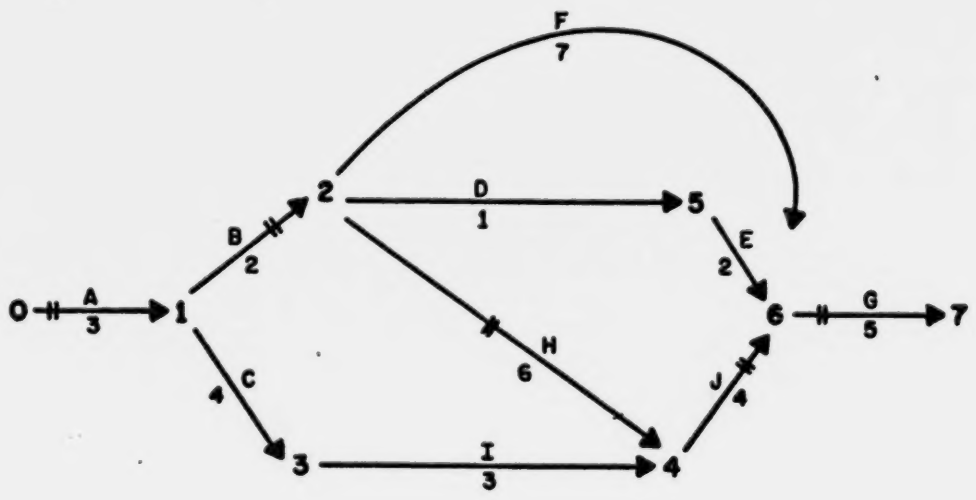
The bar chart provides the following information:

1. Job description A to J.
2. The number of working days for each of these jobs.
3. The starting and finishing dates for each of these activities.



A network diagram not only provides the *same* information but it also indicates *other significant data.*

4. Most important, the network permits an overall view of the total project. This is invaluable, since the model permits the identification of many problems prior to actual construction.



OE 6000 (9-65) DEPARTMENT OF HEALTH, EDUCATION &

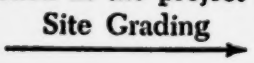
Specifically, the advantages of network diagramming over bar chart management are depicted on the chart below. The specifics of each of these points will be clarified during the presentation of CPM functioning.

DOES YOUR PRESENT MANAGEMENT DEVICE	Bar Chart		CPM	
	Yes	No	Yes	No
Clearly present an overall plan which indicates interrelationships of all participants with a *realistic* completion date?		X	X	
Indicate specific responsibilities of all parties; the architect, contractors, school officials, suppliers?		X	X	
Indicate the best course of action to be taken in the event of a real emergency? (strike, weather)		X	X	
Note exact time requirements for specific jobs, decisions and deliveries?		X	X	
Establish job deadlines during the life of the project?		X	X	
Clearly indicate amount of work completed for payment?		X	X	
Indicate effect of change orders on completion date?		X	X	
Permit critical analysis of "extras" as they affect cost?		X	X	
Specify the exact date that supplies and materials must be on the job, permitting ordering to be done well in advance?		X	X	

The first reaction to the above information would naturally cause one to ask if a new procedure can really be so superior to a system that had been used for many years. If you will carefully study the following material I believe that you will also come to realize the complete superiority of network techniques over bar chart presentations.

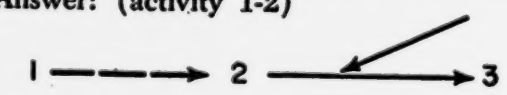
B. How Does CPM Function?

1. Each activity or function in the project is represented by an arrow.



2. An arrow may be shown in any direction. Its length is immaterial.

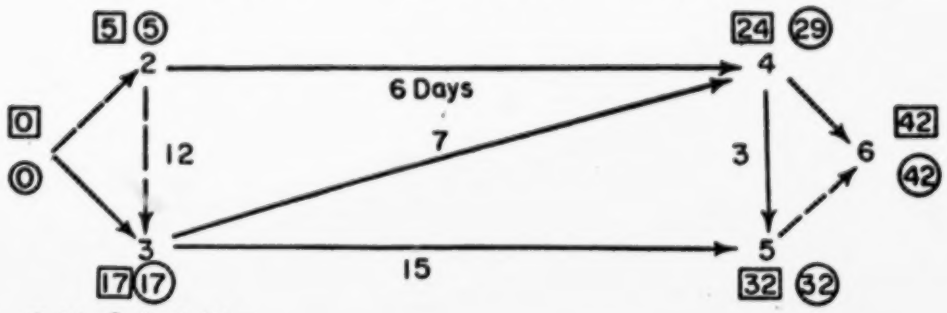
3. The network is developed logically by asking three questions about each activity.
   a. Question 1: What immediately precedes the 2-3 activity?
      Answer: (activity 1-2)



5. *Float Time*

In the following network diagram, activity 2-4 has a time duration of 6 days. If 6 days are added to the earliest start time activity 2-4, which is 5 days (indicated by [5]), activity 2-4 could be completed by the 11th day ([5] + 6 days' duration). However an examination of the network indicates that activity 2-4 may extend to the 29th day (29) without delaying the project completion. Practically, therefore, 18 additional days of time are available. These additional days are designated as float time.

[(29) − ([5] + 6 working days) = 18 days of float time]



6. *Critical Activities*

Again examining the network, we see that activity 2-3 requires 12 working days. Adding the 12 working days to the early start of activity 2-3, which is [5], the number of working days used to complete activity 2-3 is [17]. The latest date for completing activity 2-3, without delaying the project is [17]. There is no float time available.

[(17) − ([5] + 12 working days) = 0 days of float]

This is a critical activity. The sequence of critical activities taking the longest time to complete is the Critical Path. These activities normally comprise 10 to 20 percent of all the activities in a project. It is interesting to note that all of the critical activities cannot be identified without a network technique.

It is important that this method of planning permits the construction of *several* network models of the project. Then, one may choose the model most acceptable—before binding commitments have been made.

Completion Date

The length of the Critical Path also determines rather accurately the normal completion date of the project. Any compression of the original project life must be accomplished by action on the critical activities. Likewise delays caused by weather, strikes or other circumstances during the project can best be offset by additional work on the identified critical activities. The identification of the critical activities permits a minimum of time, money and manpower to be expended in order to achieve positive results. This is particularly true toward the end of a project when there has been a tendency

to crash all activities in an attempt to bring a project in on schedule. It is interesting to note that school projects are being completed in far less time than was previously thought possible.

Computer Printout

The simplicity of the network diagram used in the previous explanations permits the ready determination of mathematical applications. However, when a full-scale project involving thousands of separate activities is studied, a computer can more easily provide the required date in a readily usable form.

I	J	Dur	Job Description	Early Start	Early Finish	Late Start	Late Finish	Float Total
1	2	10	State App. of Plans	4-01-63	4-15-63	4-01-63	4-15-63	0
2	3	15	Bid & Award Period	4-15-63	5-06-63	4-15-63	5-06-63	0
3	4	8	Contr. Set Up Excav.	5-06-63	5-16-63	5-07-63	5-17-63	1
3	6	15	Ord. & Del. Flr. Joists	5-06-63	5-27-63	5-06-63	5-27-63	0
3	99	25	Ord. & Del. Joists & Fr.	5-06-63	6-11-63	5-10-63	6-17-63	4
4	5	5	Inst. Util. & Vapor Bar	5-16-63	5-23-63	5-20-63	5-27-63	2
4	6	6	Pour Ftgs. & Walls	5-16-63	5-24-63	5-17-63	5-27-63	1
5	6	0	Dummy	5-23-63	5-23-63	5-27-63	5-27-63	2

It is important to note that the network and printout are modified according to the project needs determined by the consulting engineering organization providing the CPM program. This "updating" is usually done on a monthly or biweekly basis, depending on the complexity of the project. Such information is conveyed to the owner or his representative and then to the project participants at the project conferences.

C. When May CPM Be Used?

1. Best advantage is gained if its use is started at the project's conceptual stage. Thus, administrative actions involving state approvals, site approvals and other preliminary activities are included in the plans.
2. CPM provides a distinct advantage if a preliminary plan (network) and schedule (time allocations) are included in original bid documents. Most reputable consulting firms will include a one-day seminar for bidders to review CPM procedures.
3. Following the awarding of bids, a detailed working plan and schedule is developed for the direction of the project.
4. CPM has been used when it was obvious that a project was in trouble. While the results have been beneficial, in all cases the preferred procedure as noted previously is recommended.

5. CPM may be used for only one stage of the project but this is not recommended for maximum advantage.

6. It should be noted that updating procedures constitute a basic function of the CPM program. By properly using the updating procedures, the Abington School District was able to make up approximately 37 days of delay caused by strikes and bad weather.

Summary of Advantages

Even with such a brief review of CPM, it is hoped that the specifics of the advantages noted below may be understood.

FINANCIAL	Owner	Architect	Contractor
a. Working with a network enables all participants to schedule their work more effectively, which in turn increases production and can result in sizeable savings.	X	X	X
b. A maximum return on bond money which is invested according to a planned program on payments for work completed.	X		
c. Proper use of float in assigning manpower eliminates "over-manning" and radical changes in the labor force.			X
d. Knowing a realistic completion date permits the contractors to bid on subsequent work without affecting the present project.		X	X
e. Extras can be documented and their effect on the project cost and life can be clearly determined.	X	X	X
f. Knowing when materials will be needed permits effective ordering, minimum storage and minimum cash tie-up.		X	X
g. The responsibility for project delays are clearly identified, thus giving meaning to liquidated damage clauses.	X	X	X
h. Only critical jobs are crashed when time must be made up.	X	X	X
i. If CPM is applied in the *very early* planning for a project, construction may be scheduled at a time of maximum advantage to the owner. It has been estimated by reliable sources to approximate as much as 5% of the cost of some projects.	X		
j. Considering the above, there is the distinct possibility of lower construction bids for the owner.			

Management	Owner	Architect	Contractor
a. A realistic completion date is determined prior to the beginning of the project.	X	X	X
b. Budgets, personnel and other pertinent programs may be properly planned well in advance of a project completion.	X	X	X
c. If the program is desired in minimum time, all of participants are aware of the problems which are clearly indicated on the model network.	X	X	X
d. The effect of delays due to weather and strikes can be minimized.	X	X	X
e. The network coordinates the functions of all project participants throughout the life of the project.	X	X	X
f. A network may include all of the time demands made on administrators and boards of directors in obtaining approvals, financing, design, shop drawing, etc. A time compression of this management function may save money at construction time.	X		
g. The maximum utilization of expensive equipment or services may be determined from the network.		X	X
h. The network establishes individual and interdependent responsibilities of the owner, architect, and contractors, which are written into the specifications.	X	X	X
i. The system permits non-technical personnel to exercise effective management functions for which only the owner (School Board, Authority, etc.) is responsible.	X		

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

"PERMISSION TO REPRODUCE THIS COPYRIGHTED MATERIAL HAS BEEN GRANTED BY Kenneth R. Widdall, Exec. Secy, N.C. Educ. For. Comm
TO ERIC AND ORGANIZATIONS OPERATING UNDER AGREEMENTS WITH THE U.S. OFFICE OF EDUCATION. FURTHER REPRODUCTION OUTSIDE THE ERIC SYSTEM REQUIRES PERMISSION OF THE COPYRIGHT OWNER."

EF 000793